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APPLICATION FOR UNITED STATES LETTERS PATENT

Title: **NONWOVEN WEBS MANUFACTURED FROM ADDITIVE-LOADED MULTICOMPONENT FILAMENTS**

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SPECIFICATION

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NONWOVEN WEBS MANUFACTURED FROM ADDITIVE-LOADED MULTICOMPONENT FILAMENTS

Field of the Invention

The invention relates generally to nonwoven webs and, more particularly, to nonwoven webs of multicomponent filaments loaded with surfactant and methods of manufacturing such nonwoven webs.

Background of the Invention

Nonwoven webs and their manufacture in meltspinning devices have been the subject of extensive development resulting in a wide variety of materials for numerous commercial applications. Nonwoven webs consist of a sheet of overlapped or entangled filaments or fibers of melt-processable thermoplastic polymers manufactured using spunbond and meltblown processes. A spunbond process generally involves extruding a curtain of semi-solid filaments of one or more thermoplastic polymers from multiple rows of fine orifices in a spinneret and attenuating or drawing the extruded filaments with drag forces created by a high-velocity flow of process air. Spunbond filaments are generally continuous and may have average diameters in the range of about 10 to 20 microns. A meltblown process generally involves pumping a

thermoplastic polymer from an extruder through a die to form a curtain of fibers and directing a high pressure gas stream at the exit of a die to attenuate the fibers while they are in their extensible molten state. Meltblown fibers may be continuous or discontinuous and are usually smaller than 10 microns in average diameter. The filaments or fibers are deposited on a moving collector in a substantially random manner thereby forming a continuous-length nonwoven web.

As many thermoplastic polymers are normally hydrophobic, the thermoplastic filaments or fibers must be modified to produce a nonwoven web that is water permeable or hydrophilic. One modification technique involves mixing a surfactant with the thermoplastic polymer before extrusion so that the fibers or filaments are impregnated with surfactant upon extrusion. The surfactant migrates or diffuses to the external surface of the impregnated fibers or filaments in a process called blooming. Surfactant migration may occur during and/or after filament formation and may be coerced by heating. Alternatively, the filaments or fibers may be surface-treated with a chemical agent by a conventional post-deposition topical treatment. One type of post-deposition surface treatment involves dipping the nonwoven web in a treatment bath containing a surfactant. Another type of post-deposition surface treatment involves coating or spraying the nonwoven web with a treatment solution containing a surfactant.

Surfactant-treated nonwoven webs in an article are susceptible to surfactant loss when exposed to stresses capable of removing the surfactant. Surfactant may be transferred from the external surface of a surfactant-treated nonwoven web to a contacting hydrophobic material, such as when an article

containing the surfactant-treated nonwoven web is packaged and stored. As a specific example, surfactant is transferred from top sheets in hygienic articles to contacting hydrophobic surfaces of the hygienic article and/or to the product packaging when compression packaged and stored before use. As a result, the hygienic article will not perform as expected when used or has a shortened shelf life the top sheet gradually loses its ability to transfer liquids, and. Elevated temperatures experienced during shipping and storage may accelerate surfactant migration to contacting hydrophobic surfaces rendering them hydrophilic with a concomitant loss of barrier properties. The incremental conversion of hydrophobic surfaces further reduces product shelf life.

Surfactant also tends to be removed from the surfactant-treated nonwoven web by recurring exposure to an aqueous medium. For example, washing cycles gradually diminish the hydrophilicity of a surfactant-treated nonwoven web. As another example, when used as a top sheet in a hygienic absorbent article, a surfactant-treated nonwoven web loses its aqueous permeability with accumulating exposures to soilings by aqueous body fluids.

It would be desirable, therefore, to provide a nonwoven web treated with a chemical agent or additive, such as a surfactant, that can better withstand stresses and adverse conditions such as those discussed above.

Summary

The invention provides a multicomponent filament having a sheath region of a first melt-processable polymer and a core region of a second melt-processable polymer encased within the sheath region. The core region includes an additive distributed with a first concentration that, over time and

with the occurrence of stresses, migrates outwardly from the core region to the sheath region due to the presence of a concentration gradient decreasing in a radially outward direction. The first melt-processible polymer of the sheath region operates to impede the radial migration of additive from the core region to the filament's external surface.

In certain embodiments of the invention, the sheath region may initially contain a concentration of the additive that is smaller than the first concentration of the additive in the core region. Alternatively, the additive may be absent from the sheath region when the filaments are formed. In other embodiments of the invention, the sheath region may contain a second concentration of an additive that differs in chemical composition from the additive in the core region, where the additives produce the same web characteristic. The additive(s) may be a concentration gradient of surfactant that produces a hydrophilic web or other non-surfactant additives, such as colorants, anti-static agents, lubricants, flame retardants, antibacterial agents, softeners, ultraviolet absorbers, and polymer stabilizers in which the non-surfactant additive migrates from the core region to the sheath region and external filament surface.

In accordance with the principles of the invention, a nonwoven web is manufactured by heating two thermoplastic polymers to a flowable state and adding a concentration of an additive, such as a surfactant, to at least one of the two thermoplastic polymers. The thermoplastic polymers are combined to form multicomponent filaments each having a core region of the additive-containing thermoplastic polymer and a sheath region of the other thermoplastic polymer, which may also include a concentration of an additive.

The multicomponent filaments are collected to form the nonwoven web. If the additive is a surfactant, the period over which the non-woven web exhibits effective hydrophilicity may be extended as the sheath region impedes the radial migration of additive from the core region to the filament's external surface.

The nonwoven web of the invention may be used in diverse commercial product applications including, but not limited to, hygienic articles such as diapers, adult incontinence products, and feminine hygiene products. Nonwoven webs loaded with surfactant in accordance with the principles of the invention may be used as a top sheet for an absorbent medium in a hygienic article. Articles formed from nonwoven webs of such surfactant-loaded filaments will demonstrate a lengthened shelf life and an improved performance when subject to successive wettings by liquids. Additionally, high fiber basis weight nonwoven webs require an internal surfactant or bloom additive to insure hydrophilicity without the need to fully wet the material with a conventional topical treatment. Such topical treatments are disadvantageous as these relatively-thick nonwoven webs must be dried throughout their full thickness, which is time consuming and adds needless cost to the production of a hydrophilic nonwoven web. In accordance with the invention, the surfactant is not applied topically as a surface treatment and, as a result, the nonwoven web does not have to be dried.

These and other objects and advantages of the present invention shall become more apparent from the accompanying drawings and description thereof.

Brief D scription of th Figur s

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description given below, serve to explain the principles of the invention.

Fig. 1 is a diagrammatic view of an apparatus for forming a nonwoven web in accordance with the principles of the invention;

Fig. 2 is a multicomponent filament in accordance with the principles of the invention;

Fig. 3 is an axial cross-sectional view of the multicomponent filament of Fig. 2;

Figs. 4-6 are end views of multicomponent filaments in accordance with alternative embodiments of the invention; and

Fig. 7 is a perspective view of a hygienic article in accordance with the principles of the invention.

Detailed Description of the Preferred Embodiments

The invention is directed to nonwoven webs having a lengthened property, such as hydrophilicity, formed from multicomponent filaments including a sheath and a core embedded in the sheath, in which the core has a concentration of an additive, such as surfactant, that serves as a reservoir for replenishing additive depleted from the sheath. Although the invention will be described herein as being manufactured by an exemplary meltspinning system, it should be understood that modifications to the exemplary system described herein could be made so as to conform any portion or the entire system to

produce any type of airlaid nonwoven web or a collection of unbonded filaments or fibers without departing from the intended spirit and scope of the invention.

With reference to Fig. 1, a spunbonding apparatus 10 is equipped with a pair of extruders 12, 14 that each convert a solid thermoplastic polymer into a molten state and provide the molten thermoplastic polymers under pressure to a corresponding set of gear pumps 16, 18. Extruder 12 is provided initially with a solid mass of Polymer A from a bulk source 20, and extruder 14 is provided initially with a solid mass of Polymer B from a bulk source 22, which are replenished from bulk sources 20, 22 as consumed during the melt spinning process. The gear pumps 16, 18 pump metered amounts of each thermoplastic polymer to an extrusion die or spinneret 24, which has a spin pack that combines the thermoplastic polymers and discharges a curtain of multicomponent filaments 26 constituted collectively by the two thermoplastic polymers. For ease of reference, one thermoplastic polymer provided to spinneret 24 will be referred to as Polymer A, while the second thermoplastic polymer provided to spinneret 24 will be referred to as Polymer B. As will be understood in accordance with the principles of the invention, other embodiments may utilize more than two thermoplastic polymers. An exemplary multiple-component spin pack for a spinneret 24 is disclosed in U.S. Patent Number 5,162,074, which is hereby incorporated by reference herein in its entirety.

The descending airborne curtain of multicomponent filaments 26 are quenched with cross-flow cooling air, as represented by arrows 28, from a quench blower (not shown) to accelerate solidification and drawn through a filament-drawing device 30. The filament-drawing device 30 applies a

tangential high velocity flow of process air, as represented by arrows 31, in a direction substantially parallel to the length of the multicomponent filaments 26. Because the multicomponent filaments 26 are extensible, the drag force of the spunbonding process pneumatically attenuates and molecularly orients the multicomponent filaments 26. The multicomponent filaments 26 discharged from the filament-drawing device 30 are deposited in a substantially random manner as a nonwoven web 32 on a horizontally and linearly moving perforated collector 34. The collector 34 moves in a machine direction, represented by the arrow labeled MD, that represents the length of the nonwoven web 32 in the direction in which it is produced. The collector 34 also spans the width of the curtain of multicomponent filaments 26 in a cross-machine direction perpendicular to the machine direction and into and out of the plane of the page of Fig. 1.

Additional spunbonding apparatus, not shown but similar to spunbonding apparatus 10, and meltblowing apparatus (not shown) may be provided downstream of spunbonding apparatus 10 for depositing one or more spunbond and/or meltblown nonwoven webs of either monocomponent or multicomponent filaments on nonwoven web 32. An example of such a multilayer laminate in which some of the individual layers are spunbond and some meltblown is a spunbond/meltblown/spunbond (SMS) laminate made by sequentially depositing onto a moving forming belt first a spunbond fabric layer, then a meltblown fabric layer and last another spunbond layer.

With continued reference to Fig. 1, a surfactant from a surfactant source 36 is added along with the mass of Polymer B from bulk source 22 to the hopper of extruder 14. A mass or volume of the surfactant is blended,

preferably homogenously, with Polymer B to create a mixture that is pumped by gear pump 18 from the extruder 14 to the spinneret 24. The surfactant may be any suitable chemical agent that increases the hydrophilicity of the multicomponent filaments 26 so that nonwoven web 32 is wettable by and has the strong ability to absorb an aqueous medium containing water or another liquid. A mass or volume of a surfactant from a different surfactant source 38 may be mixed with the mass of Polymer A from bulk source 20 added to the hopper of extruder 12 and pumped by gear pump 18 from extruder 12 to spinneret 24. In this manner and consistent with the principles of the invention, each of the thermoplastic polymers provided to the spinneret 24 may include a surfactant concentration.

The surfactant may be blended with the thermoplastic polymer in a dry form, such as powder or pellets, using conventional mechanical mixing techniques before being placed into the hopper of either extruder 12, 14. Mechanical mixing techniques using devices for homogenizing an admixture of powders and pellets, such as V-blenders or double cone blenders, are familiar to persons of ordinary skill.

The melt-processable thermoplastic polymer or polymers used to fabricate the multicomponent filaments 26 may be any of the commercially available spunbond grades of a wide range of thermoplastic polymer resins, copolymers, and blends of thermoplastic polymer resins, including without limitation polyolefins such as polyethylene and polypropylene, polyesters such as polyethylene terephthalate, polybutylene, polyamides, nylons, polyvinyl acetate, polyvinyl chloride, polyvinyl alcohol, cellulose acetate, and blends and copolymers thereof. The invention contemplates that each of the thermoplastic

polymers (Polymers A and B) constituting the multicomponent filaments 26 may be identical in base composition and differ only in the concentration of the added surfactant. For example, the core may be formed from polypropylene containing a concentration of surfactant and the sheath may be formed from polypropylene having identical material characteristics and a lower concentration of surfactant. Most of these thermoplastic polymer resins are hydrophobic and, therefore, are rendered hydrophilic (wettable) by the presence of the surfactant at the external surface. The surfactant may also be added to normally hydrophilic thermoplastic resins for enhancing their wettability.

Typically, the surfactants supplied by the surfactant sources 36, 38 may be identical, although the invention is not so limited. Each surfactant may be classified as a fast wetting surfactant that causes liquids to permeate the nonwoven web 32 at a fast rate or, alternatively, as a low wetting surfactant which causes liquids to permeate the nonwoven web 32 at a relatively slow rate. Each surfactant must be miscible with the associated thermoplastic polymer so as to be capable of forming homogeneous mixtures. Each surfactant may be anionic, cationic, amphoteric or non-ionic, in which non-ionic surfactants are believed to be less irritating to human skin tissue. Preferred non-ionic surfactants include, but are not limited to, sorbitan esters, ethoxylated sorbitan esters, silicone copolymers, fluorochemical-based surfactants, alcohol ethoxylates, alkylphenol ethoxylates, carboxylic acid esters, glycerol esters, polyoxyethylene esters of fatty acids, polyoxyethylene esters of aliphatic carboxylic acids related to abietic acid, anhydrosorbitol esters, ethoxylated anhydrosorbitol esters, ethoxylated natural fats, oils, and waxes, glycol esters

of fatty acids, carboxylic amides, diethanolamine condensates, monoalkanolamine condensates, polyoxyethylene fatty acid amides, and polyalkyleneoxide block copolymers.

With reference to Figs. 2 and 3, the thermoplastic polymers constituting each multicomponent filament 26 are arranged a sheath/core configuration in which one thermoplastic polymer (Polymer B) is disposed in a core 40 surrounded by a sheath 42 of the other thermoplastic polymer (Polymer A). The core 40 and sheath 42 each extend continuously along the length of each multicomponent filament 26 and are coextensive along an annular or cylindrical interface 43. The core 40 and sheath 42 may be arranged coaxially in a concentric configuration with the sheath 42 radially outward of the core 40.

In accordance with the principles of the invention and with reference to Figs. 2 and 3, a surfactant 44a is present in the core 40 in a greater concentration than a surfactant 44b in sheath 42. Preferably, the concentration of surfactant 44a in Polymer B constituting the core 40 is about 5% by weight to about 10% by weight, and the concentration of surfactant 44b in Polymer A constituting the sheath 42 ranges up to about 3 % by weight, typically about 1% by weight to about 3% by weight. In certain specific embodiments of the invention, Polymer A may be the same thermoplastic polymer as Polymer B and the chemical composition of the surfactant in each of the polymers may be identical.

In accordance with the principles of the invention, the surfactant 44a initially present in the core 40 will tend to diffuse or migrate from the region of high concentration across the interface 43 to the region of low concentration in the sheath 42, as represented by the arrows labeled with reference numeral

41. Molecules of surfactant 44b initially present at an external surface 48 of the sheath 42 produce hydrophilicity or wettability. Surfactant molecules at the external surface 48 of the sheath 42 are lost, as represented by the arrows labeled with reference numeral 47, by contact with another hydrophobic surface or by repeated wetting with liquid. Amounts of surfactant 44b and surfactant 44a present in sheath 42 migrate to the external surface 48 as represented by the arrows labeled with reference numeral 49. The radially outward migration reduces the surfactant concentration in the sheath 42. As the surfactant concentration drops in the sheath 42, surfactant 44a migrating from the core 40 into the sheath 42 replenishes the depleted concentration of surfactant 44a and surfactant 44b. As a result, the nonwoven web 32 (Fig. 1) will remain hydrophilic for a longer period after manufacture when packaged and with repeated exposure to liquids. The surfactant 44a in the core 40 serves as a reservoir for surfactant transfer, as required or otherwise on a time-delayed basis due to the difference in concentration, across the annular interface 43 to the sheath 42 and subsequently to the external surface 48.

With reference to Fig. 4 and in accordance with an alternative embodiment of the invention, sheath 42 may contain no surfactant 44b at least at the moment of discharge from the spinneret 24 (Fig. 1). Surfactant 44a migrates from the core 40 into the sheath 42 and subsequently to the external surface 48 makes the multicomponent filament 26 hydrophilic. The initial migration occurs subsequent to discharge of the multicomponent filament 26 from the spinneret 24, such as during web processing to complete web formation, during web processing to form an article, and while the web and/or article are stored before the time of use.

The invention contemplates that the chemical composition of the surfactant 44a may differ from the chemical composition of the surfactant 44b. In this alternative embodiment, surfactant 44a is not present in the sheath 42 (i.e., has a zero concentration) at least at the moment of discharge from the spinneret 24 (Fig. 1). The hydrophilicity of the multicomponent filament 26 is supplied initially by molecules of surfactant 44b present at the external surface 48. Due to the concentration disparity, surfactant 44a migrates radially outwardly from the core 40 into the sheath 42 and amounts of surfactant 44a eventually reach the external surface 48. Eventually, surfactant 44a is lost from the external surface 48 along with with surfactant 44b. Amounts of surfactant 44b lost from the external surface 48 are replenished by the outward migration of stored amounts of surfactant 44b from the sheath 42. Surfactant 44a lost from the external surface 48 is replenished by amounts of surfactant 44a migrating from the underlying sheath 42. The store of surfactant 44a in the sheath 42 is replenished by migration of amounts of surfactant 44a from core 40. The migration and loss of surfactant 44a may be independent of the migration and loss of surfactant 44b or the migration and loss of surfactants 44a,b may be interrelated.

By adjusting the relative concentrations of the surfactants 44a,b in the two thermoplastic polymers (Polymers A and B), the shelf life of the surfactant-treated nonwoven web 32 may be significantly extended as the hydrophilic nature of the external surface 48 is lengthened by the net transport or migration of surfactant 44a from the relatively-high surfactant concentration present in the core 40 into the sheath 42 and to the external surface 48. In addition to the gradient in surfactant concentration, the migration rate from the

core 40 to the sheath 42 and from the sheath 42 to the external surface 48 is also influenced by other factors, including the sheath thickness, the chemical properties of the surfactant(s), the environmental temperature, extrusion conditions, and the characteristics of the thermoplastic polymer(s). In particular, the diffusion of a surfactant in a thermoplastic polymer depends upon the affinity between the surfactant and the thermoplastic polymer. The affinity varies among the different possible combinations of thermoplastic polymer and surfactant, which will influence transfer of surfactant 44a from the core 40 to the sheath 42 and surfactant 44a and surfactant 44b from the sheath 42 to the external surface. Accordingly, the affinity between the selected surfactant and the thermoplastic material forming the core 40 should permit surfactant transfer from the core 40 to the sheath 42. Likewise, the affinity between the thermoplastic polymer forming sheath 42 and surfactant 44a will influence migration of surfactant 44a from the sheath 42 to the external surface 48. Similarly, the affinity between the thermoplastic polymer forming sheath 42 and surfactant 44b will influence migration of surfactant 44b from the sheath 42 to the external surface 48.

The invention contemplates that one or more non-surfactant additives, such as compatibilizing agents, colorants or pigments, optical brighteners, ultraviolet light stabilizers, antistatic agents, abrasion resistance enhancing agents, nucleating agents, fillers and/or other additives and processing aids, may be added in a concentration gradient to one or more of the polymers constituting multicomponent filaments 26. In these various alternative embodiments, the non-surfactant additive is added to filaments 26 with a greater concentration in the core 40 than in the sheath 42, as described

herein with specific regard to surfactant. The subsequent additive migration of the non-surfactant additive(s) radially outward from the core 40 lengthens or sustains the manifestation of a corresponding property(ies) or a characteristic(s) of the filaments 26. The invention contemplates that one or more of the non-surfactant additives may be distributed in multicomponent filaments 26 in a manner similar to the concentration gradient of surfactant, as described herein, either jointly with the surfactant or in the absence of surfactant.

With reference to Fig. 5 and in accordance with an alternative embodiment of the invention, multicomponent filament 26 may have a core 50 that is offset or non-concentric within a sheath 52 so as to have an eccentric or asymmetrical configuration. With reference to Fig. 6 and in accordance with another alterative embodiment of the invention, the thermoplastic polymers of multicomponent filament 26 may have an "islands-in-the-sea" configuration in which multiple core regions 60 of Polymer B reside inside a sheath 62 of Polymer A. Although the components of filament 26 are depicted in Figs. 2-6 as having round cross-sections, the invention contemplates that the nonwoven web 32 might be formed from filaments (not shown) of different cross-sectional shapes.

With reference to Fig. 7, a disposable hygienic article 70 generally includes a top sheet 72, a back sheet 74, a fluid storage layer 76 separating the top sheet 72 from the back sheet 74, and a fluid acquisition and transfer layer 78 separating the fluid storage layer 76 from the top sheet 72. The top sheet 72, which faces and contacts the wearer, is fluid pervious so that aqueous body fluids may readily penetrate through its thickness to the fluid storage layer 76.

Fluid acquisition and transfer layer 78 distributes aqueous body fluids transferred from top sheet 72 to the underlying fluid storage layer 76, which includes an absorbent material capable of absorbing large quantities of aqueous body fluids and retaining the absorbed body fluids under moderate applied pressures. The back sheet 74 prevents aqueous body fluids absorbed in the fluid storage layer 76 from wetting items in the surrounding environment, such as pants, pajamas and undergarments. Loop-type fasteners 80 on the back sheet 74 cooperate with hook-type fasteners 82 on corresponding attachment tabs 84 extending laterally of the back sheet 74 cooperate for attaching the hygienic article 70 to a wearer.

In accordance with the principles of the invention, all or part of the components of hygienic article 70, including but not limited to the top sheet 72 and the back sheet 74, may incorporate portions of a nonwoven web formed from the multicomponent filaments of the invention. The invention contemplates that various other consumer and commercial articles may incorporate a portion of a nonwoven web formed from the multicomponent filaments of the invention.

While the present invention has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. For example, the multicomponent filaments from which the nonwoven web of this invention is made may be produced by meltblown processes as well known to persons of ordinary skill in the art. The invention in its broader aspects is

therefore not limited to the specific details, representative apparatus and methods, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicants' general inventive concept. The scope of the invention itself should only be defined by the appended claims, wherein we claim: